

Technology in Practice

What, Why & How?



TIP 7 - Creating and Using Three Point Curves for Laboratory Trial Batches

This TIP outlines the process of developing lab trial batch information for mixture submittals

WHAT is a Three Point Curve and HOW Do You Use It?

A three-point curve is a simple way, to obtain a relationship between one factor that is varied to 3 different levels and a measured result using the least number of experiments. All other factors are kept constant. For concrete mixtures the three-point curve is used to establish mixture proportions for selected project requirements. The typical measured result is the compressive strength and the one factor that will be varied in three different trial batches of concrete is the cementitious content or the water to cementitious materials ratio (w/cm). When more than one factor is changed, a more complex designed experiment will be necessary to establish the required relationships or a separate three-point curve relationship can be established.

When a predictive relationship is established from a three-point curve, it can be used to select the varied quantity (cementitious content or w/cm) for a specific target measured value (strength). It can also be used in reverse. For example, the relationship can be used to predict the resulting strength from a known w/cm.

When developing a three-point curve, the selected factor should not be varied in too large increments. For instance, the increments in cementitious materials content generally should not be more than about 150 lbs/yd³ and the increments in w/cm should generally not be more than about 0.15. This relationship can then be used for more than one strength level of concrete required for a project. An established three-point curve relationship should not be used if another factor is varied. For example, a three-point curve established for non air-entrained concrete should not be used to predict strengths of air-entrained concrete.

It may be desirable to include a “fourth” point when planning the experiment. This allows one to evaluate whether the relationship is truly linear and to ignore erroneous points that might bias the desired relationship. One should never connect only two points to establish these relationships. Additionally, predictions should not be made outside the range of the established relationship.

WHY Is This Important?

A three point curve is an effective tool for the concrete producer to evaluate the performance of various types of material combinations. Three-point curves of concrete mixtures are also used for project submittals as required in the ACI 301 specification for structural concrete. Project specifications indicate specified strength, f'_c , for different concrete uses on a project. To ensure that the concrete meets the strength acceptance criteria, the concrete producer develops mixture proportions to attain the target average strength, f'_{cr} , that is greater than the specified strength. The process of arriving at the target or required average strength, f'_{cr} , is described in TIP 2. The proposed mixtures, with accompanying test data, are submitted to the engineer of record to permit the project to move forward.

Laboratory or production trial batches using a three-point curve are typically conducted if the class of concrete required by the project specification has not been developed or used by the concrete producer recently; when field data are not available; or when new materials or sources of materials are used in concrete mixtures. Three-point curves are used to develop the test data for a family of mixture proportions for a given mixture class (same material sources, and supplementary cementitious material dosages) and is more effective than developing mixture proportions for each type of concrete required.